



Software Instruments for Analysis and Visualization of Game-Based Learning Data

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Abstract. With the development of technology, the consumer requirements of users of educational video games are constantly changing, determining the need for integration and use of tools for monitoring information, data, activity related to the processes of creating, designing, managing, and playing educational video games. This paper is based on the authors’ research and publications on the development of specialized software tools and their implementation in the educational software platform APOGEE (smArt adaPtive videO GamEs for Education). We present an initial prototype of an online system for learning and gaming analytics of playing enriched educational maze games and discuss issues of its system design such as the software architecture, the organization of its data model, and the user interface. The integration of these tools in the software platform will provide the necessary functionalities for data monitoring, data processing, and evaluating the individual results of the learners.

Keywords: Analytics · Educational games · Software instruments · APOGEE

1 Introduction

Educational video games are a popular topic that is gaining daily interest from practitioners, researchers, and educators, as well as the growing number of users of educational video games. The benefits of the application of educational video games in the process of teaching students by video games (so-called game-based learning) have been proven in many scientific publications and scientific developments [1–4]. It is definitely considered that, with the development of technology, the consumer requirements of users of educational video games are constantly changing. This is one of the reasons that determine the need for integration and use of tools for monitoring information, data, activity related to the processes of creating, designing, managing, and playing educational video games.

This paper is based on the authors’ research and publications on the development of specialized software tools for the application of Taxonomy of Instruments for Facilitated Design and Evaluation of Video Games for Education (TIMED-VGE) [5], the design of the basic functionality of these tools [6, 7], and their implementation in the educational

software platform APOGEE (smArt adaPtive videO GamEs for Education) [8, 9]. Educational video games definitely need data to meet the rapidly changing and dynamic user requirements of different stakeholders for a specific design and architectural environment [10], for educational games with defined and personalized educational goals, and rich educational resources [11] – learning content, and captivating educational games and learning user experience through “game-based learning” (playing user-experience).

The focus of this paper is on developing such tools to support educational video game-play and design. In this paper, we present a collection of learning and gaming analytics software instruments and their progressive and partial integration into the APOGEE software platform.

The paper presents the initial prototype of an online system for learning and gaming analytics of playing enriched educational maze games, which makes a part of the assessment and visualization tools of the APOGEE platform. It discusses issues of its system design such as the software architecture, the organization of its data model, and the user interface. Special attention is paid to tracking of learning and playing progress of the individuals conforming to the APOGEE student model. Next, the paper reveals how this content management system is integrated into the APOGEE platform for the design and creation of educational video games.

The integration of these tools in the software platform will provide the necessary functionalities for data monitoring, data processing, setting various metrics on the data, and defining criteria for evaluating both the individual data/results of each of the learners and the overall process of designing, creating, managing and evaluating educational video games. The processed data from the analytics tools and their visualization of the users, through various methods of data and insights visualization, will serve as a basis for performing additional analyses and improvements of the educational maze games designed by applying specific educational game-based learning scenarios. These improvements will enhance both the playability and learnability of educational video mazes enriched by various puzzle mini-games embedded into the halls of the maze, together with the personalization of the learning contents based on specific characteristics of the player model.

The paper is organized as follows: the paper will proceed with the introduction of the analytics instruments of the APOGEE platform developed by applying the TIMED-VGE taxonomy. Section 3 will present the development of the Online System for Learning and Gaming Analytics of Playing Enriched Educational Maze Games, including the descriptions of the software architecture, the organization of its Data Model, and the user interface. The paper ends with a brief discussion and a conclusion.

2 Background Works

As we stated in the introduction of this paper, we base our research on previous publications [5–7], presenting the development of the APOGEE software platform instruments and their main capabilities. The APOGEE software platform for educational video games consists of two main categories of software instruments – assistive and analytics instruments.

As presented in Fig. 1 [5, 7], the analytics instruments are divided into three groups as follows: *Learning Analytics*, *Gaming Analytics*, and *Analytics for Users*. The process

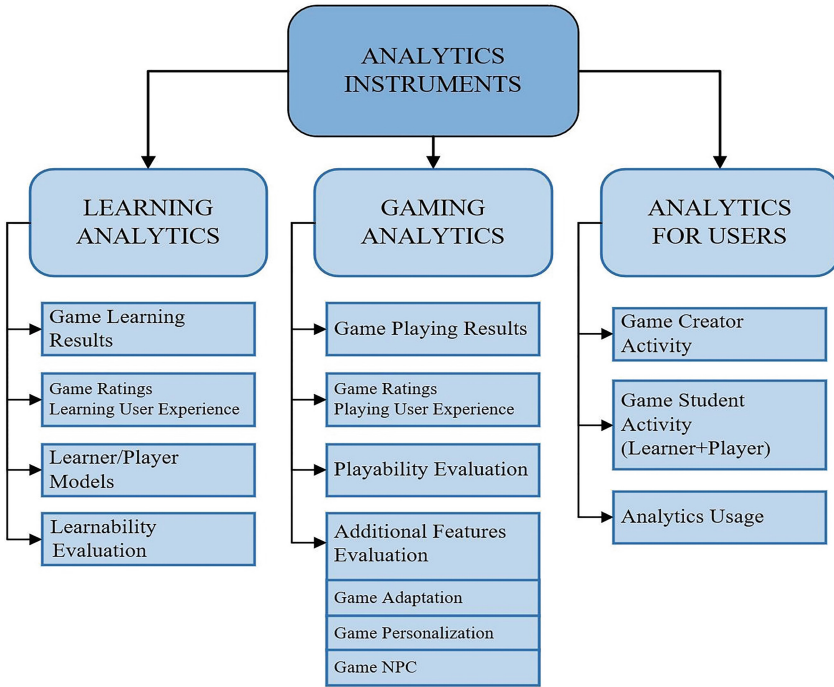


Fig. 1. Application of the TIMED-VGE for the development of the analytics instruments in the APOGEE software platform [7] based on [5]

of developing and designing the functionalities of the Analytics instruments is described in [7]. The Analytics instruments in the APOGEE platform will serve as useful tools to bridge the gap between the abundance of data and the user’s need for the relevant data [12]. These tools provide the necessary functionalities for data monitoring, data processing, data visualization, and evaluation of both the individual data and learners’ results, as well as the overall process of designing, creating, managing, and evaluating educational video games. For the purposes of this study, this paper focuses primarily on the *Analytics instruments*.

3 Online System for Learning and Gaming Analytics of Data About Playing Enriched Educational Maze Games

3.1 Software Architecture

The created online system for learning and gaming analytics of data about playing enriched educational maze games provides all the analytics instruments presented in Fig. 1. In order to show learning and gaming analytics, teachers have to create and deploy on the server their educational mazes (enriched with various mini-games representing appropriate didactic tasks) and students have to provide self-report (by filling quizzes about basic characteristics, playing/learning style, and game playability/learnability).

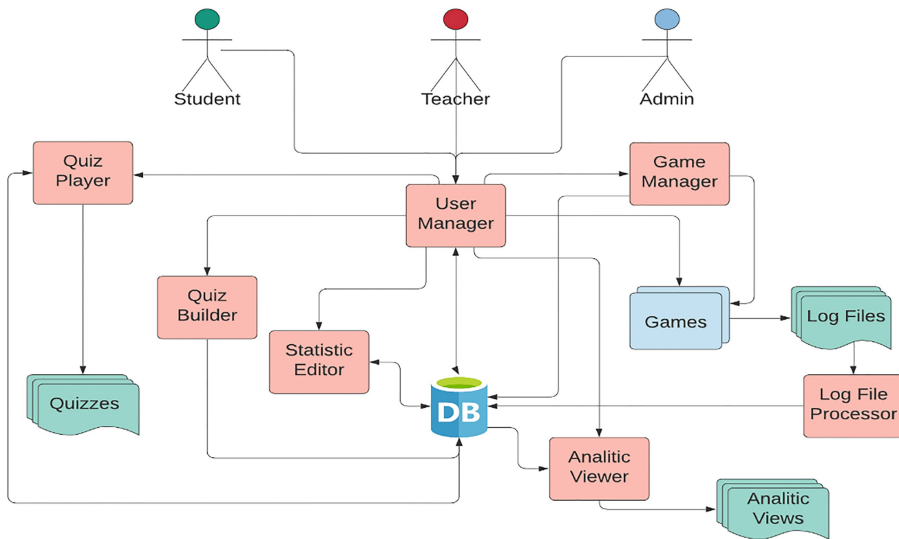


Fig. 2. Software architecture of the system

Figure 2 provides a simplified view of system architecture. Teachers, students and administrators log to the system through the User Manager module. Next, teachers use Quiz Builder to construct their quizzes and Game Manager to deploy their games, while students can play each game once or more times. For each game session, a log file is created. The Log File Processor applied the detailed log file data for calculating and preserving into the database (DB) learning and gaming features like outcomes, effectiveness, efficiency, time, and others. Description of the software architecture. The administrators apply a Statistic Editor for saving into DB various statistics and formulas for their calculation, like correlations, p value, etc. The Analytics Viewer presents playing data together with selected statistics for these data and results from self-reports obtained by the Quiz Player.

3.2 The Organization of Its Data Model

In this subsection, we present the organization of the APOGEE Data Model of the Instruments of the APOGEE Software Platform. We illustrate the model in Fig. 3 with the following diagram.

Figure 3 shows the data model of the main instruments of the APOGEE software platform. It presents the main entities that store data and information in the APOGEE database. The model includes a classification of 26 entities that are interconnected and specifically related to each other with the respectable relationships described in the model. At the centre of the model is the *Users* entity which stores all data and information about the users of the APOGEE platform. The system users can have different roles (described as *Role* entity in the model) such as Admin, Content User, Game Creator, or Student. The *User* entity is also directly interconnected with the entities *Games*, *Game Assets*, *Learning Contents*, *Maze Game Results*, *Puzzle Games Results*, *Other Student*

Data, Playing Styles, Quizzes, Quiz Question Responses. Each of these entities stores specific and defined data and information.

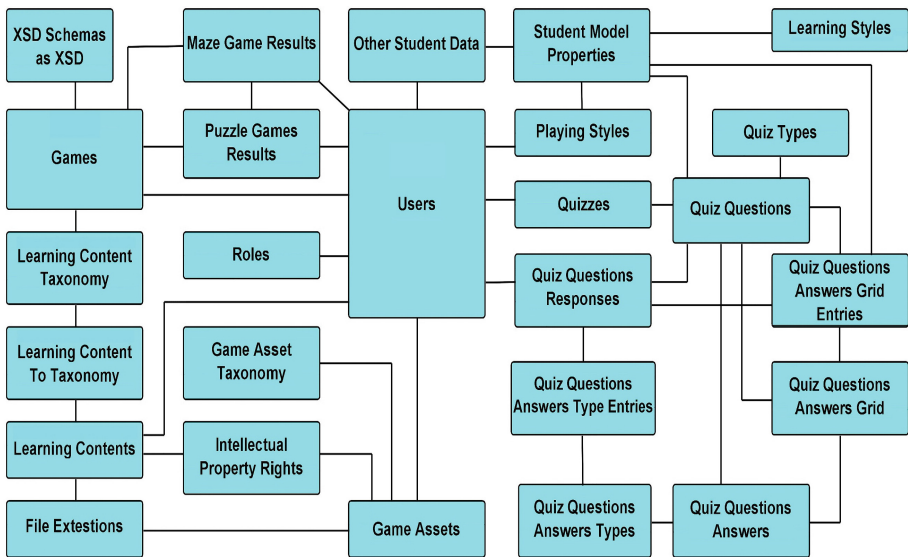


Fig. 3. The data model of the instruments of the APOGEE software platform

We managed to present the Data Model of the Instruments of the APOGEE Software Platform as simplified as possible for the purpose of this paper and to use this model as a base for further development of the initial prototype of an Online System for Learning and Gaming Analytics playing enriched educational maze games.

3.3 Organization of the System User Interface

The organization of the system user interface realizes the functionalities of the online system for learning and gaming analytics of data about playing enriched educational maze games. Figure 4 provides a simplified view of the organization of the main user interface pages of the system used by students and teachers (pages for administering the system are now show here). All the users should first registered at the system (with e-mail and password), in order to be able to log into. After a successful login, teachers can upload their educational maze game (not show in Fig. 4). Students can edit their profile (including names, nickname, email, and password) and answer some questions:

- about their basic student properties (such as age, gender, school grade, experiences in fun gaming and in educational game playing, learning goals, playing goals, and initial knowledge in the learning subject);
- about their learning style;
- about their playing style.

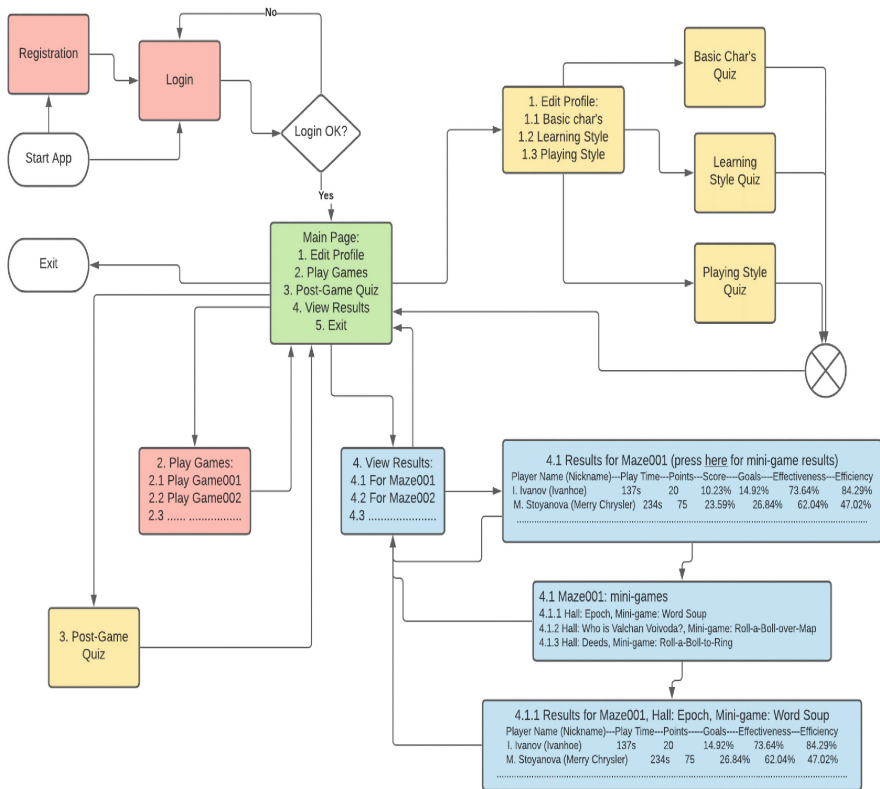


Fig. 4. Organization of the main user interface pages of the system

Students can answer the questions of the basic characteristics and learning and playing styles as many times as they like. Next, they are allowed to play gaming sessions with anyone of the maze games deployed and registered by the teachers. In order to be able to see their results about given maze game (like Game001) – together with the results of the other players – students have to answer at least once the questions of the post-game quiz, which is regarding game learnability and playability. Next, they are allowed to see the results for playing the maze Game001 and, if like, to check their results for all the mini-games contained in the halls of the Game001maze. For viewing these results, students should select the name of the mini-game they are interested in. Their results are shown together with the results of the other students played the same mini-game. Figure 5 presents the students’ result for the mini-game “Word Soup” available at the maze hall named “Epoch”.

Teachers are able to see the same results from the game playing sessions, as the students do. Moreover, teachers see the analytics menu shown down in Fig. 4, where they can select two data columns and a statistic to be applied for them such as Pierson correlation r , Student T-test (p value), Cohen effect size d , etc. For this purpose, the formulas for calculation of these statistics should be saved to the DB (through the Statistic Editor).

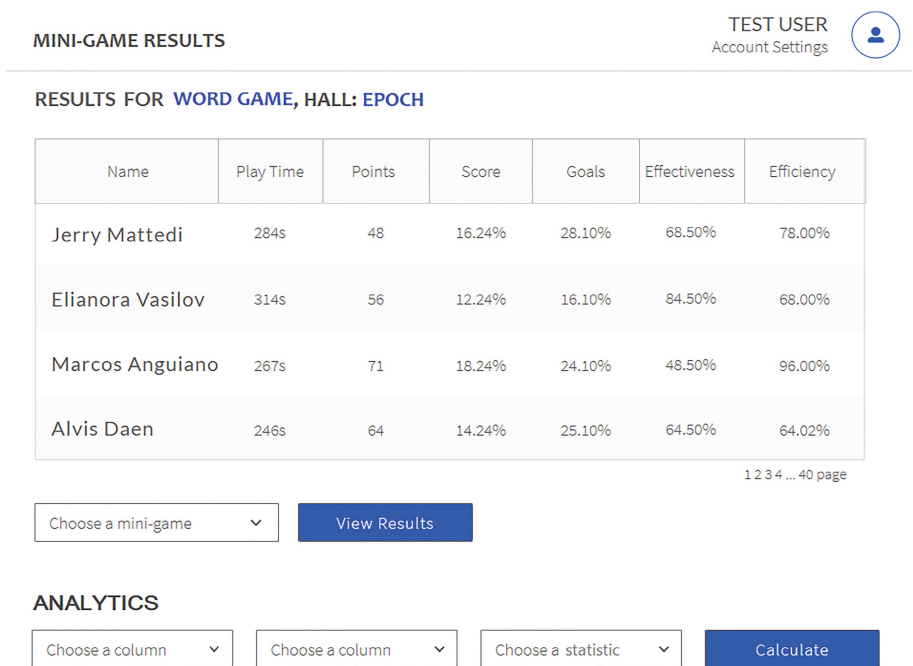


Fig. 5. A view of a web page showing results about playing a Mini-Game

4 Conclusion

The paper presented the initial prototype of an online system for both learning and gaming analytics of playing enriched educational maze games as part of the assessment and visualization tools of the APOGEE platform. The Data Model of the Instruments of the APOGEE Software platform presents the main entities that store all data and information in the APOGEE database and describe the relationships between those entities. The user interface is presented with a description of the UI organization and a description of the Web page. We argue that the integration of “Analytics Instruments” in the APOGEE software platform will provide the necessary functionality for data manipulation and extraction of valuable data insights and will serve as a basis for further analysis and improvements of educational maze games and development of the APOGEE software platform itself.

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